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A New Color Variant of the Mycoheterotrophic Orchid *Gastrodia fontinalis* from Takeshima Island, Japan

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A new color variant of *Gastrodia fontinalis* f. *albiflora* from Takeshima Island, Kagoshima Prefecture, Japan, is described. The new form, *G. fontinalis* f. *albiflora*, is separated from *G. fontinalis* f. *fontinalis* only by coloration of the outer surface of the perianth tube (white vs. pale brown), the inflorescence (pale greenish brown vs. dark greenish brown), hypochile (whitish orange vs. red), and the epichile (whitish orange vs. brownish red). The ecological significance of this whitish form of *Gastrodia fontinalis* is also discussed.

Key words: *Gastrodia*, new form, mycoheterotroph, Orchidaceae

Gastrodia (Orchidaceae) comprises approximately 50 species of mycoheterotrophic orchids distributed throughout temperate and tropical regions of Asia, Oceania, Madagascar, and Africa (Chung & Hsu 2006). The genus is characterized by fleshy tubers, the absence of leaves, the union of sepals and petals, and the production of two mealy pollinia lacking caudicles (Pridgeon *et al*. 2005, Chen *et al*. 2009, Cribb *et al*. 2010, Hsu & Kuo 2010, 2011, Hsu *et al*. 2012).

Extraordinary morphological diversity is exhibited within *Gastrodia*. Some species of section *Gastrodia* (*sensu* Schlechter 1911) can reach 60–100 cm in height during flowering. In contrast, many species of section *Codonanthus* (Schlechter 1911, Tuyama 1967) have inflorescences only 3–15 cm long at flowering time, but during fruiting they become 30–40 cm long and have elongated pedicels (Chung & Hsu 2006). As with most mycoheterotrophs, during the flowering season, species belonging to section *Codonanthus* are rarely found. Until the 1970's, only four species of section Codonanthus had been recorded (Satomi 1982): *G. boninensis* Tuyama, *G. confusa* Honda & Tuyama, *G. gracilis* Blume, and *G. nipponica* (Honda) Tuyama. Since then, seven additional species have been recognized: *G. clausa* T. C. Hsu, S. W. Chung & C. M. Kuo (Suetsugu *et al*. 2013), *G. flexistyloides* Suetsugu (Suetsugu 2014), *G. fontinalis* T. P. Lin (Suetsugu *et al*. 2014), *G. pubilabiata* Y. Sawa (Sawa 1980), *G. takeshimensis* Suetsugu (Suetsugu 2013a), *G. shimizuana* Tuyama (Tuyama 1982, Kobayashi & Yukawa 2001, Suetsugu *et al*. 2012), and *G. uraiensis* (Suetsugu 2015a).

Interestingly, mycoheterotrophic plants sometimes exhibit distinct color variation of not only floral but also vegetative parts (e.g. Fukunaga *et al*. 2008, Suetsugu 2012a,b, Tsukaya & Okada 2012, Suetsugu & Yagame 2014) because selective pressure for photosynthetic pigments is relaxed in mycoheterotrophs. In *Gastrodia*, two greenish forms *G. javanica* (Blume) Lindl. f. *thalassina* Yokota and *G. confusa* Honda et Tuyama f. *viridis* Suetsugu have been reported (Yokota 1990, Suetsugu 2012a). Recently, I found

FIG. 1. Flowering individual of *Gastrodia fontinalis* T.P. Lin f. *albiflora* Suetsugu, from type locality, 11 April 2015 (Photo by Kenji Suetsugu).

flowering individuals of *Gastrodia fontinalis* with white flowers on Takeshima Island, Kagoshima Prefecture, Japan. They are described below.

Taxonomic treatment

Gastrodia fontinalis T. P. Lin f. **albiflora** Suetsugu, **forma nov.**—Fig. 1

Herbs, terrestrial, mycoheterotrophic. Root short, densely branching, mostly extending from center of apex of rhizome system. Rhizome tuberous, fusiform or cylindrical, 6–12 cm long, 6–9 mm in diameter, dark brown, covered with numerous scales. Inflorescence erect, pale greenish brown, 7–13 cm long, 2.5–4 mm in diameter. Bracts ovate, ca. 8 mm long. Pedicel and ovary ca. 10 mm long. Flowers 1–7, bell-shaped, slightly nodding or oriented slightly upward, resupinate, 16–20 mm long, ca. 10 mm in diameter. Sepals and petals united, forming a 5-lobed perianth tube. Sepals subsimilar, fleshy, 17–21 mm long, connate ca. 2/3 length of petals, lateral sepals connate with each other ca. 3/5 their length, outer surface white, slightly verrucose, margins entire; free portion of dorsal sepal straight, ovate-triangular, retuse, 6–7 mm long, ca. 7 mm wide; free portions of lateral sepals spreading, apex obtuse. Free portion of petals ovate or elliptic, ca. 4.5 mm long, 3.5 mm wide. Lip adnate to column foot, 8 mm long; calli of hypochile 2, whitish orange, globose; epichile whitish orange, ovate-triangular, base contracted, with 6–8 elevated ridges on upper portion, with 2 ridges extending to orange to red ligulate apex. Column straight, terete, ca. 8 mm long, 2–2.5 mm wide, white tinged with pale green at base; column foot well developed; lateral wings (stelidia) narrow, brown, edges parallel to column, apex acute; rostellum small; stigma located at base. Anther hemispheric, ca. 1 mm in diameter, pollinia 2.

Typus. Japan, Kagoshima Pref., Takeshima Island. (*Kenji Suetsugu s.n., April 11, 2012*, Holotype in KYO).

Japanese name. Shirobana-tokara-yatsushiro-ran, nov.

Distribution. To date, *Gastrodia fontinalis* f. *albiflora* appears to be restricted to the type locality. The population contains ca. 10 white-flowered individuals in a bamboo forest dominated by *Pleioblastus linearis* (Hack.) Nakai. The bamboo forest is not as dense as in the habitat of the typical form of *G. fontinalis.* As a result, the habitat is exposed to relatively high light intensity. The litter surrounding *G. fontinalis* f. *albiflora* is dry and whitish. The population is ca. 50 m distant from the nearest population of typical *G. fontinalis.*

Flowering was observed from late March to mid April.

Notes. Gastrodia fontinalis f. *albiflora* can be separated from *G. fontinalis* f. *fontinalis* by the coloration of the outer surface of the perianth tube (white vs. pale brown), inflorescence (pale greenish brown vs. dark greenish brown), hypochile (whitish orange vs. red), and epichile (whitish orange vs. brownish red; Suetsugu *et al*. 2014). There are no clear differences in morphology (other than coloration) between these two. In particular, we could not distinguish differences in the morphology of the lip and column, which is an important characteristic for distinguishing the species of Gastrodia. In addition, while *G. fontinalis* f. *fontinalis* bears 1–16 flowers per inflorescence (Suetsugu *et al*. 2014), *G. fontinalis* f. *albiflora* has 1–7 flowers, therefore tending to have fewer flowers per inflorescence in the 10 individuals observed during the present research trip to Takeshima Island. However, given the fungal nature of mycoheterotrophs, it may be no surprise that there is great variability in flower number, depending on nutritional conditions. I therefore treat these individuals as a color variant.

Plant pigmentation is a vital component in biological processes, such as pollinator interactions, while selective pressure for photosynthetic pigments is relaxed in mycoheterotrophs. Although the diverse array of floral coloration among angiosperms is often attributed to divergent selection by pollinators (Newman *et al* 2012), pollinator-mediated floral coloration selec-

tion in *Gastrodia fontinalis* is unlikely because both forms of *G. fontinalis* are pollinated by species of *Drosophila*, whose key attractants are scent rather than visual signals (Suetsugu, unpublished data).

An additional aspect of plant coloration is avoidance, particularly in reference to defense against visually guided herbivores. Herbivores are often nitrogen-limited and thus attracted to plants with high nitrogen content such as mycoheterotrophs (Cleland & Harpole 2010, Roy *et al.* 2013, Suetsugu 2013b, 2015b). Thus, a strong priority of mycoheterotrophs would be the selective avoidance of herbivores. Most mycoheterotrophs are not as white as albino mutants of autotrophic and mixotrophic plants (Leake 1994); this likely works to enhance homochromy with the forest surroundings, thus providing camouflage defense against herbivores. Indeed, the role of camouflage is demonstrated in the mycoheterotrophic *Monotropsis odorata*, which is highly homochromous with surrounding the leaf litter due to its brown shoot scales (Klooster *et al.* 2009). Interestingly, concordance between the surrounding leaf litter color and the plant's coloration can be seen in *Gastrodia fontinalis* [i.e. *G. fontinalis* f. *fontinalis* tends to grown among black dirt or decomposed dark litter (Suetsugu *et al.* 2014) whereas *G. fontinalis* f. *albiflora* grows in dry, whitish litter (Fig. 1)]. Thus, it is worth investigating whether the white coloration of *G. fontinalis* f. *albiflora* allows was selected to blend in with the light colored leaf litter to reduce attack by herbivores.

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